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THEORETICAL INVESTIGATION OF NON-EQUILIBRIUM CHEMISTRY
AND OPTICAL RADIATION IN HYPERSONIC FLOW FIELDS

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Prepared for
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National Aeronautics and
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Ames Research Center
Moffett Field, California 94035

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16. Abstract <p>Future space vehicles returning from distant missions or high Earth orbits may enter the upper region of the Earth's atmosphere and use aerodynamic drag to reduce their velocity before they skip out of the atmosphere and enter low Earth orbit. The Aeroassist Flight Experiment (AFE) is designed to explore the special problems encountered in such entries. The optical emission from the shock layer under nonequilibrium conditions causes the radiative heating rate to increase but it also provides unique data about the chemical and excitation processes occurring in the flow field. The theoretical peak radiative heating rate for the AFE flight, reported herein, is 9.5 watts/cm^2, which is about 25% of the total peak heating rate. However, the potential heating is about 1230 watts/cm^2!! but self-absorption allows only a small portion of it to reach the surface. The impact of this result on future entry vehicle designs must be verified, or refuted, during the AFE test flight.</p> <p>Planning is under way to send a probe into the atmosphere of Titan (a moon of Saturn) as part of the Cassini Mission, a cooperative project between NASA and ESA. It is shown herein that the mole fractions of N_2, CH_4 and argon in the Titan atmosphere can be determined by a simple radiometer experiment carried on the probe that measures the intensity of the CN(violet) radiation emitted in the shock layer during the high velocity portion of the entry. The experiment is simple, rugged, small, reliable and relatively inexpensive.</p>			
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**THEORETICAL INVESTIGATION OF NONEQUILIBRIUM
CHEMISTRY AND OPTICAL RADIATION
IN HYPERSONIC FLOW FIELDS**

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Moffett Field, California 94035

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The research activities funded under Cooperative Agreement NCC2-444, with Dr. Ellis Whiting as Principal Investigator, yielded the following results:

1. A computer code was developed to calculate the radiative transport along line-of-sight in the general 3-dimensional flow field about an arbitrary entry vehicle, if the temperatures and species concentrations along the line-of-sight are known.
2. The radiative heating calculation at the stagnation point of the AFE vehicle along the entry trajectory was performed, including a detailed line-by-line accounting of the radiative transport in the vacuum ultra-violet (below 200 nm) by the atomic N and O lines. A paper entitled **"Radiative Heating at the Stagnation Point of the AFE Vehicle,"** by E.E. Whiting and Chul Park, containing some sensitive information, was written on this subject, and a copy may be made available to qualified U.S. readers.

3. A paper entitled **"Titan Atmospheric Composition by Hypervelocity Shock Layer Analysis,"** describing a shock layer radiometer experiment to determine the mole fractions of nitrogen, methane, and argon in the atmosphere of Titan (a moon of Saturn) was presented at the AIAA meeting in Buffalo, NY, June 12-14, 1989. The paper has also been selected for publication in the Journal of Thermophysics and Heat Transfer. A copy of this paper is attached.

4. A method was developed for making measurements of the haze particles in the Titan atmosphere above 200 km altitude. A proposal for the **"Cassini Mission: Huygens Probe"** to make such measurements, and to determine the mole fractions of nitrogen, methane, and argon in the Titan atmosphere during the hypersonic portion of the Titan entry is being prepared. A copy of the Scientific and Technical Plan (volume 1 of six volumes) of the proposal is attached. A copy of the other volumes may be made available to qualified U.S. readers.

5. Several other tasks of a continuing nature, to improve the technical ability to calculate the nonequilibrium gasdynamic flow field and radiative heating of entry vehicles, were completed or advanced.

6. The copy of a paper entitled "Recent Advances at NASA in Calculating the Electronic Spectra of Diatomic Molecules," by E.E. Whiting and J.A. Paterson, was included in the periodic report for this grant for the period 6/1/88 through 11/30/88.